

## **Historic, Archive Document**

Do not assume content reflects current scientific knowledge, policies, or practices.



A281.359  
M342

UNITED STATES  
DEPARTMENT OF AGRICULTURE  
LIBRARY



BOOK NUMBER A281.359  
M342

2 UNITED STATES DEPARTMENT OF AGRICULTURE  
U.S. AGRICULTURAL MARKETING SERVICE .  
MARKETING RESEARCH DIVISION/  
X✓ BIOLOGICAL SCIENCES BRANCH

AERATION AND FUMIGATION SYSTEMS FOR TANK  
AND FLAT TYPE GRAIN STORAGEES

Prepared by  
Stored-Product Insects Section 1/  
May 1, 1954

Grain stored in tank and flat-type storages is subject to moisture accumulation in the surface grain, particularly if the moisture content of the bulk is near the maximum safe limit. Fumigation of grain in such storages also presents some difficulties. The following information was compiled to answer some of the questions regarding storage of grain in storages where the handling facilities of terminals are not available.

I. VENTILATION

What causes molding and caking of the surface layer of stored grain?

When grain is stored in large bulks and held from the summer through the following winter, the differences in temperature between various parts of the grain pile set up convection currents throughout the grain. As a result, there is a slow but continuous exchange of moisture from the grain in the warmest section to that which is cool. When the moisture-laden currents rising from the warmer grain come in contact with the cooler surface grain, some of the moisture is condensed in the surface grain. This process is similar to the formation of dew. The moisture movement begins with the advent of cooler weather in the fall, when the surface grain cools and the grain in the center of the bulk is still warm. The accumulations of moisture in the top 6 to 24 inches of surface grain may reach a point beyond the limits of safe storage. Under such circumstances caking and molding will occur. Heating of grain caused by insect infestation will also cause caking and molding in surface grain.

---

1/ Information pertaining to engineering phases was taken from articles published by agricultural engineers, USDA.

Does moisture movement occur in all types of storages?

Yes. The moisture transfer, however, is much more pronounced in large bulks of grain than in small ones. In lots of 1,000 bushels or less the accumulation of moisture in surface grain is seldom serious, because the grain mass is so small that great differences in temperature between interior and outer layers of grain do not occur. One of the characteristics of moisture accumulations in surface grain is that where the grain surface is uneven the greatest accumulation occurs in the highest portions.

What are the factors affecting the moisture movement and accumulation of moisture in surface grain?

These are:

1. The average moisture of the stored grain;
2. The size of the storage structure;
3. The length of the storage period;
4. The difference between the atmospheric temperatures and the temperature of the grain; and
5. The amount of insect infestation.

Will cooling the grain control excessive moisture accumulations?

Yes, if the grain is cooled by forced ventilation with cool, dry, outside air.

Is raking the grain surface effective in controlling moisture?

Tests have indicated that less caking and molding occurred when the grain was raked, but raking had little effect on the reduction or prevention of the accumulation of moisture in the surface grain.

What methods are used in cooling grain?

- (1) Stored grain can be cooled by using fans connected to ventilating tunnels or ducts installed in the storage structure before filling with grain. In quonsets or other flat storage, installations as shown in figures 1, 2, 3, and 4 can be used. With an air movement of 0.1 c.f.m. per bushel the grain will be cooled to approximately atmospheric temperatures in about one week, regardless of the size or shape of the bin, if the air is distributed uniformly. The system shown for 40,000-bushel storages in figures 1 to 4 supply about this volume and require  $1\frac{1}{2}$  h.p. for shelled corn.
- (2) For a 10,000-bushel circular bin equipped with a perforated floor or a duct system, a  $\frac{1}{2}$ -h.p. fan is required (fig. 5).



- (3) For a 3,200-bushel circular bin a  $\frac{1}{4}$ - to  $\frac{1}{2}$ -h.p. fan is required provided the bin is equipped with a perforated tube or duct (figs. 6 and 7).
- (4) For steel tanks of 350,000-bushel capacity equipped with ducts, 50 h.p. is required (figs. 8 to 12). These oil tanks were 117 feet in diameter and 41 feet to the eaves, and were equipped with a system of floor ducts and wall and roof vents. Air could be introduced through the vents (fig. 8) and roof openings, and by means of the portable blower (fig. 9) drawn down through the grain, and out through the floor ducts (figs. 10, 11, and 12).

The floor duct system consisted of two main ducts extending across the center of the tank floor, from which smaller ducts led off at intervals of 10 feet to the perimeter of the tank. The two main ducts were 30 inches in diameter at the point of exit, and were gradually reduced to a diameter of 12 inches at the opposite wall (figs. 10 and 12). The smaller lateral ducts were 8 inches in diameter at the connection with the main duct and 6 inches at the walls (figs. 10 and 11). The ends of all the ducts were closed with metal caps. All ducts were of 14-gage corrugated galvanized iron (figs. 10, 11, and 12).

Provision was made for the passage of air through the ducts by a series of  $\frac{1}{2}$ -inch holes punched at 1-foot intervals in the corrugation of the undersides of the ducts. The force of the air traveling through the system was not powerful enough to lift the grain up into the ducts, so no clogging of the system took place.

The ends of the two main floor ducts were connected on the outside of the tank to the intake or suction side of the two super-blast fans that were used to aerate the grain (figs. 8 and 9).

When used for aeration of grain, the air is drawn in through the openings in the top of the tank, down through the grain, and exhausted to the outside through the fans. (See section on fumigation for use of this system in recirculating fumigant gases.)

- (5) In storages of from 3,000 to 10,000 bushels, 15 feet deep or less, which are not equipped for air circulation before filling, sections of perforated ducts can be sunk vertically into the grain from the top surface. The 4- to 8-foot section of perforated pipe, 4 inches in diameter, is connected to a 4-foot solid pipe of the same diameter and sunk vertically into the grain so that about 3 feet of the solid pipe is below the surface of the grain. The insertion of the vertical pipe can be accomplished by pushing it down and using either the suction of a pneumatic conveyor or a household vacuum cleaner for drawing the grain out of the inside of the pipe as the

pipe is pushed down. Ordinary galvanized iron 4-inch down spouting can be inserted to a depth of 10-12 feet if the grain is withdrawn as the pipe goes down. In this system 0.01 to 0.02 c.f.m. per bushel may be used if the fan is operated continuously from early fall to mid-winter. The intake of a small centrifugal fan (1/3-h.p.) is connected to the pipe and the exhaust from the fan piped so as to exhaust outside the storage structure.

The vertical pipes should be spaced so that no high moisture or heated spots remain in the grain after aeration.

- (6) Wind ventilation. Work now in progress indicates that, when properly designed, wind ventilators are efficient in cooling grain. The ventilators work on the principle of drawing cold, outside air into the grain and dispersing it throughout the grain mass. This method is still in the experimental stage, and no recommendations can be made at this time.

How much perforation is necessary in the duct system?

Tubes or ducts should have at least 7 percent perforation.

How many bins can be cooled with one fan?

One fan for each two bins is recommended, for the reason that in a sudden drop in atmospheric temperature all bins will need attention at once.

Which way should the air flow through the grain, upward or downward?

The fan assembly should be connected to the ventilating system so that air will be drawn downward through the grain. If air is forced upward through the grain some condensation of moisture occurs when the upward-moving air comes in contact with the cold surface grain and the cold roof of the storage structure.

When should cooling be started?

Cooling should be started as soon as the weather begins to cool in the fall. In some areas cooling can be started in September. The fan should be operated continuously when the average daily outside air temperature is 10° F. or more below the highest grain temperature. The fan should not be operated during periods of rain, snow, fog, or high humidity, as operation during such periods can add considerable moisture to the grain. Humidistat controls can be installed to stop electrically driven fans during periods of high humidity.



When should cooling be stopped?

The fan should be operated until the temperature of the exhaust air is near the average outside air temperature. One thermometer can be placed in the connection between the bin and the fan and one in a shaded outside location to determine when the air leaving the grain and the outside air are about the same temperature.

Is it necessary to recool grain after initial cooling?

Yes. After the initial cooling in early fall, the grain should be cooled again when the average winter temperature of the outside air reaches about 32° F. After the grain has been cooled to near the freezing point, further cooling should not be necessary. In addition to its effect on moisture accumulation, cooling will quickly destroy insect infestation in the grain, if the temperature of the grain can be maintained near the freezing point for a week or longer. Periodic observations of the moisture content of the surface grain are recommended. If an increase in surface moisture is noted, additional cooling can be done to prevent excessive moisture accumulation in the surface grain.

If warm air in the overspace is drawn down through cold grain, will moisture be condensed in the grain?

There may be a slight amount of condensation, but it will not be serious unless the air has high humidity. The practice is not good, however, because the grain should be permitted to remain cool as long as possible.

What is the cooling effect of drawing warm, dry air, through warm, wet grain?

The air will tend to carry off heat as fast as it is generated, thus preventing a rise in temperature. If the grain is wet there will be some evaporative cooling. However, if the grain is wet enough that the temperature of the ventilated grain goes substantially below the air temperature, it should be dried and the equipment we are talking about is not adequate. The systems described herein are not drying equipment and any reduction in moisture content resulting from its use is only incidental.

What is the maximum length of ventilating duct that can be used effectively?

There is no limit, provided the duct is sized properly. For grain depths of 12 feet or more a maximum velocity of 1,500 to 2,000 feet per minute should be observed.

How far apart should ducts be placed in flat storages of a width in excess of 40 feet?

The duct spacing should not be greater than twice the depth of the grain. A closer spacing is desirable.

What is the maximum depth of grain that can be cooled with the duct system?

Bins as deep as 120 feet and probably deeper can be cooled but the power requirement increases with the depth.

## II. FUMIGATION

How is the aeration system converted for use in fumigation?

The aeration system in steel tanks or metal bins can also be used to distribute fumigant by closing the system (figs. 8 and 13) and recirculating the fumigant gas. The fumigant is introduced into the exhaust duct of the fan, blown into the tank over the top of the grain, drawn down through the grain, and out through the floor ducts to the fan, which again blows it into the top of the tank. The recirculation of the fumigant in this manner greatly aids in obtaining a uniform distribution of the gas throughout the grain mass.

What rate of air flow is necessary to distribute the fumigant uniformly?

Air flow of 0.1 c.f.m. per bushel of grain has proved to be sufficient to distribute fumigant gases uniformly throughout the grain mass. A lower rate of air flow is permissible if distribution of the gas can be accomplished within 30 minutes or less.

What fumigant should be used?

To date only methyl bromide has been tested, but the common grain fumigants no doubt would give good results provided they were vaporized before introduction into the circulation system.

What is the proper dosage?

A dosage of 3 pounds of methyl bromide per 1,000 bushels, circulated for 30 minutes, gave excellent results in sorghum grain. For other grains, the dosages have not been established, but would probably be less than the dosage for sorghum grain. Dosages for other fumigants have not been determined.

What about the fumigation of flat storages?

No recommendation can be made at present on the fumigation of grain in flat storage by the recirculation method. Exploratory tests have indicated that recirculation of methyl bromide in flat storages equipped with ventilating ducts offers a promising means of controlling insect infestations.







Figure 1.--Exhaust fan and fan housing connected to ventilation duct in a quonset of 25,000-bushel capacity. The fan is connected to a duct running the full length of the structure. (See figure 2.)



Figure 2.--Fabricated steel duct used in flat storage ventilation. Duct is covered with window screening to prevent grain from filling the tunnel.





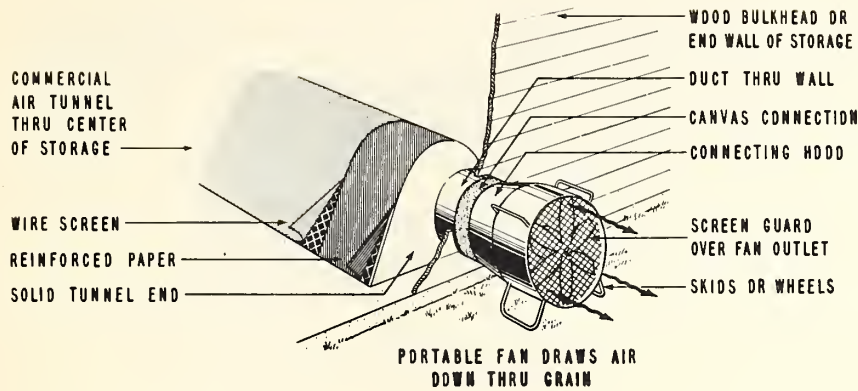


Figure 3.—Cooling fan connected to flat storage structure equipped with commercial tunnel. Fan is shown with direct-connected electric motor; fan can also be belt-driven with gasoline or electric motor.

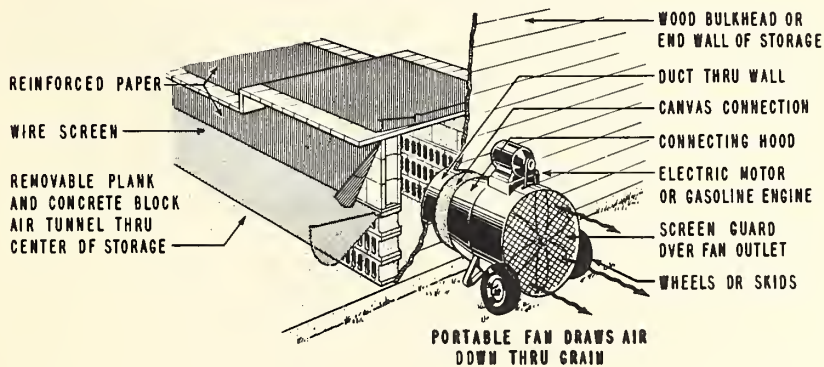


Figure 4.—Cooling fan connected to flat storage structure equipped with tunnel constructed with concrete blocks, boards, and window screening.



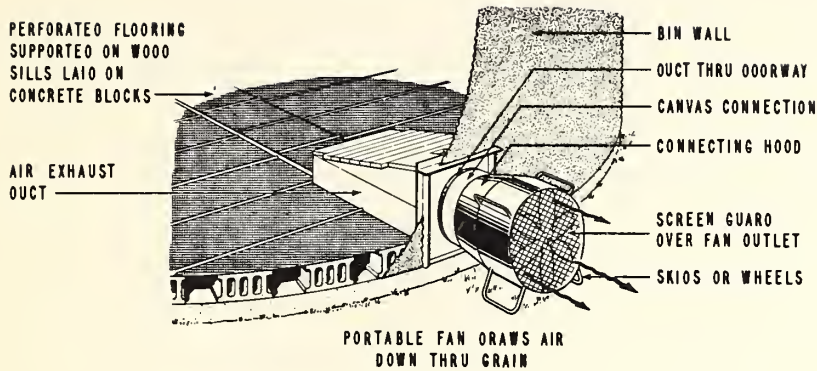


Figure 5.--Cooling fan connected to circular bin equipped with perforated floor. See figure 13 for blower installation.

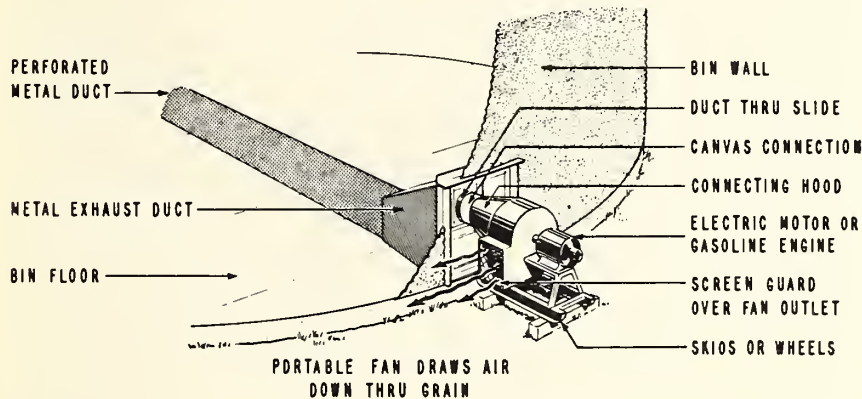


Figure 6.--Cooling fan connected to a 3,200-bushel bin equipped with a perforated duct or tunnel. See figure 13 for blower installation.





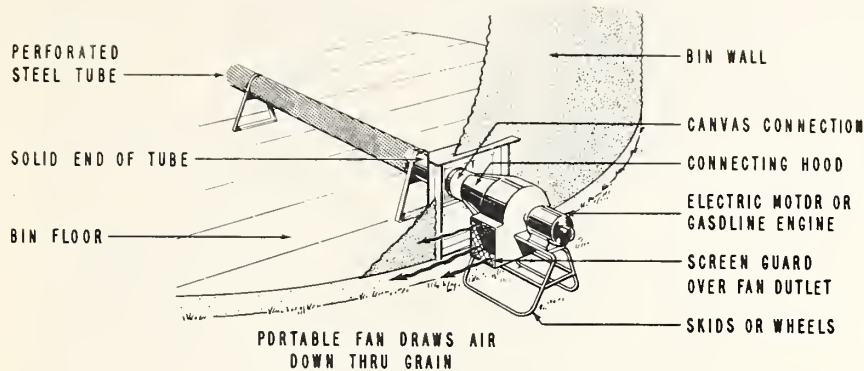


Figure 7.--Cooling fan connected to a 3,200-bushel bin equipped with a perforated tube. Centrifugal fans of the proper size may be simpler to connect to the smaller tubes than propeller fans because of the smaller fan inlet. See figure 13 for blower installation.

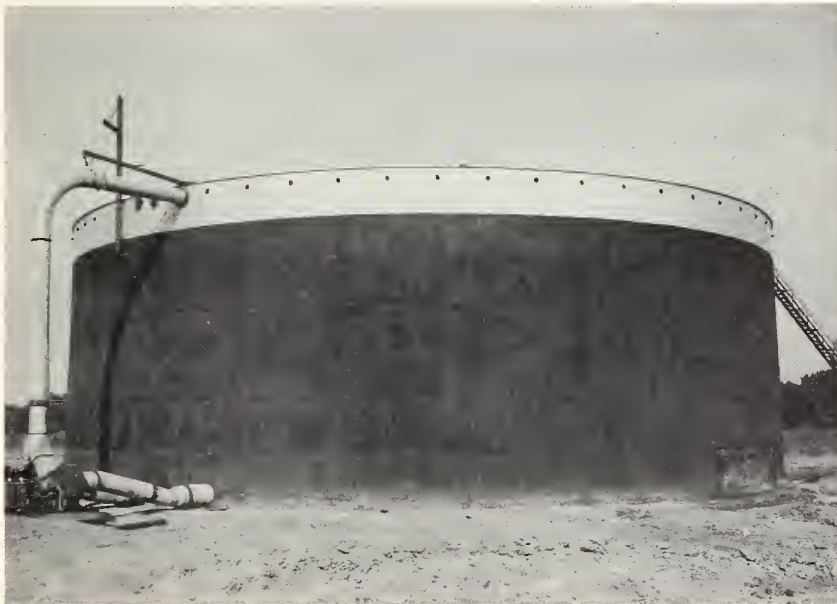


Figure 8.--Oil tank 117 feet in diameter, 40 feet to the eaves, 385,000-bushel capacity, equipped with a ventilating-fumigating system. Black dots just below eaves are capped pipe nipples. Caps are removed during ventilation, closed when fumigating. Duct disconnected at eaves when system is used for ventilation.



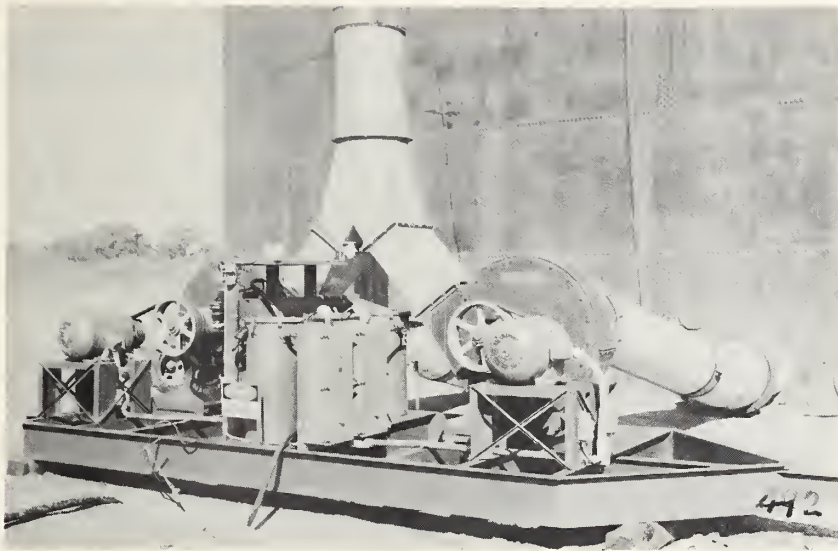


Figure 9.--Close-up of twin fans powered with 25-h.p. electric motors.  
Twin ducts lead from bottom of tank to fans.



Figure 10.--Floor duct system in tank shown in figure 8, showing main  
duct with laterals leading to perimeter of tank.





Figure 11.--Floor duct system in tank shown in figure 8, showing method of carrying a lateral duct around a roof supporting member.



Figure 12.--Floor duct system in tank shown in figure 8, showing method of attaching lateral ducts to main duct.







Figure 13.--A circular metal bin of 3,300-bushel capacity equipped to recirculate fumigant. See figures 5, 6, and 7 for duct systems in this type of bin. A wooden, inverted V-duct raised 2 inches off the floor may be substituted for the metal ducts.



